HOLD FOR RELEASE
UNTIL PRESENTED
BY WITNESS
March 7, 2007

Statement of
Michael H. Freilich
Director, Earth Science Division
Science Mission Directorate
National Aeronautics and Space Administration

Before the
Committee on Commerce, Science and Transportation
Subcommittee on Space, Aeronautics and Related Sciences
United States Senate

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the President's FY 2008 budget request for NASA's Earth Science program. I welcome the chance to discuss the important area of Earth Science, especially in light of the recently released National Research Council's Earth Science Decadal Survey.

NASA's FY 2008 budget request includes $1.5 billion for the study of planet Earth from space. This represents an increase of $27.7 million over the FY 2007 budget request, and will fund a wide-ranging and balanced program of activities, including: developing, launching, and operating Earth-observing space missions; competitively selected research and analysis science investigations conducted by NASA and non-NASA researchers; Applied Science projects that help other federal and regional agencies and organizations to efficiently use products from NASA Earth research to advance their missions; ongoing technology development efforts to enable the missions of the future; and, education and public outreach programs to make our knowledge of the Earth accessible to the world. NASA's budget request supports a balanced program, allocating over 30% of NASA's request for the Science Mission Directorate and within the Science Mission Directorate, allocating 27% of funding for Earth Science.

NASA remains by far the largest single contributor to the interagency U.S. Climate Change Science Program (CCSP). Much of the science community's present state of knowledge about global change -- including many of the measurements and a significant fraction of the analyses which serve as the foundation for the recent report of the Intergovernmental Panel on Climate Change (IPCC) -- is derived from NASA's Earth Science program. To list just a few examples, using data from Earth observing satellites NASA-supported researchers are: monitoring ice cover and ice sheet motions in the Arctic and the Antarctic; quantifying the short-term and long-term changes to the Earth's protective shield of stratospheric ozone, including the positive impacts of the Montreal protocols; discovering robust relationships between increasing upper ocean temperature and decreasing primary production from the phytoplankton that form the base of the oceans' food chain; and, using a fleet of satellites flying in formation (the "A-Train") to make unique, global, near-simultaneous measurements of aerosols, clouds, temperature and relative humidity profiles, and radiative fluxes.

Our improved understanding of Earth System processes leads to improvements in sophisticated weather and climate models, which in turn – when initialized using the satellite data – can be used to predict natural and human-caused changes in the Earth's environment over time scales of hours to years.

Importantly, near-real-time measurements from NASA research missions (including the Tropical Rainfall Mapping Mission, QuikSCAT, the Atmospheric Infrared Sounder instrument on the Aqua mission, and others) are used routinely by the National Oceanic Administration (NOAA) and other U.S. and international agencies to improve weather forecasting. Similarly, high quality measurements obtained by operational weather satellites provide essential context for the scientific analyses of the NASA research mission data.

As of today, NASA is operating 14 Earth observing missions. Five more missions are quite far advanced in their development, and will be launched in 2008 and 2009. Of these, the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) and the Ocean Surface Topography Mission (OSTM) will continue critical Earth System and climate measurements that were initiated by the Earth Observing System (for NPP) and the TOPEX/Poseidon and Jason-1 missions (for OSTM). The Glory mission will fly an instrument to extend our measurements of total solar irradiance, as well as an instrument that will provide unique, first-ever measurements of properties of atmospheric aerosols. The Orbiting Carbon Observatory (OCO) and the Aquarius mission will make new, first-of-a-kind global measurements of atmospheric carbon dioxide concentrations and ocean surface salinity – both parameters of known importance to the study of climate change.

The FY 2008 budget request also funds the reconstituted Landsat Data Continuity Mission (LDCM) for launch in 2011, and the Global Precipitation Measurement Mission (GPM) for launch of its Core spacecraft not later than 2013, followed a year later by launch of the NASA GPM Constellation spacecraft. Extending the pioneering rain measurements initiated with the joint US/Japanese Tropical Rainfall Mapping Mission, and providing a calibration standard for several other rain-measuring instruments orbited by others, the GPM mission will provide us with accurate, *global* rain measurements much more frequently than currently possible. Knowledge of accurate rainfall rates and atmospheric water quantities is essential for the study of the Earth's hydrologic cycle and its sensitivity to climate change. In addition, the GPM measurements will be used by operational weather prediction agencies around the globe to improve weather forecasts and severe storm predictions.

Even as we are acquiring and analyzing measurements today, we are planning the satellites, field experiments, scientific investigations, and Earth System models of the future. The recently released Earth Science Decadal Survey provides, for the first time, a scientifically based, community consensus statement of the top priority future Earth System Science problems to be addressed, and it suggests a sequence of notional missions whose measurements could contribute to advancing our understanding of the Earth and its environment.

We welcome the Decadal Survey – indeed, we asked for it. NASA, along with NOAA and the U.S. Geological Survey (USGS), requested and funded the National Research Council (NRC) to conduct this first Decadal Survey in Earth science. We formally made the request in the fall of 2003 and the study began in earnest in 2004. The massive undertaking was only completed this January. We are grateful for all of the efforts of the Co-Chairs and NRC staff, the members of the decadal survey Executive Committee, and the literally hundreds of Earth science researchers who volunteered their time and their ideas. Their success in creating scientific consensus across the broad and diverse Earth science community is a substantial achievement.

The science priorities identified by the Decadal Survey will be our primary guide as we design and select Earth observing missions to be flown in the next 10-15 years. In the space sciences, NASA has a long history of guidance by NRC decadal surveys. Indeed, even in the Earth sciences where this is the first Decadal Survey, the President's FY 2008 budget request for NASA was guided by recommendations included in the interim report issued by the Decadal

Survey committee in 2005. The FY 2008 budget request includes funding and predictable launch dates for the Landsat Data Continuity Mission, the Glory aerosol and solar irradiance mission, and the Global Precipitation Mission, all of which figured strongly in the interim report.

Unfortunately, the Decadal Survey arrived too late for its specific recommendations to influence the FY 2008 budget process, but its scientific priorities will be used in development of the FY 2009 and subsequent budget requests. NASA's FY 2008 budget request also includes funding for an additional, unspecified, competed flight mission, which will launch sometime around 2014. We will be guided by the Decadal Survey as we choose the scientific focus and instrument complement for this mission, starting no earlier than 2008.

In addition to its science priorities and the notional mission set, the Decadal Survey provides several recommendations relevant to the design and implementation of the Earth Science flight program. Survey recommendations in the areas of international collaboration and technology investment deserve particular consideration.

We all recognize that a constellation of missions and many simultaneous measurements – such as those obtained by the A-train spacecraft described above – are needed to understand the interactions between Earth system processes. No agency or nation can afford to develop and fly all necessary missions single handedly.

The Decadal Survey emphatically recommends international collaboration, to maximize humankind's benefits from our net investment in Earth science, and to avoid unnecessary duplication. To this end, we have already begun discussions with our 5 closest international space agency partners: the Canadian, European, French, Japanese, and German space agencies. We have begun planning substantive bilateral meetings to be held this spring, to identify and refine areas of common interest and complementary expertise. We are also actively engaged – indeed NASA and the U.S. are leaders – in international coordination bodies such as the Committee on Earth Observation Satellites (CEOS) and the international Group on Earth Observations (GEO). As with our present OSTM, Aquarius, and GPM missions, we anticipate substantial joint projects with international partners as we construct missions to address the Decadal Survey's science questions.

Science-driven technology investment is one of the keys to the design and implementation of any future mission set. It is essential to have the technology developed and tested in a relevant environment prior to the approval of any mission. This helps to avoid cost overruns that occur when problems arise with a new technology late in the mission development cycle. To foster advanced technologies for Earth science, NASA's strategy is two pronged as recommended by the Decadal Survey, with both focused technology and core technology elements.

Where we know the missions we want to implement and what new technologies are required on a certain schedule, we make focused investments to assure technologies are available when we issue competitive solicitations for mission formulation and development. This is done through the highly successful Instrument Incubator Program, funded under the Earth Science Technology Office, which matures instrument technologies for future measurements.

The second prong addresses the seed corn or "core technologies," for advanced Earth observing missions of the future. Where we know that certain classes of technologies are needed for the types of measurements we would like to make in the future, or are simply convinced that investment in certain sensor or detector technology areas will yield fruit, we will issue open, competitive solicitations for the best ideas. Examples include advanced component development (which allows scientists and technologists to take an idea from the concept to the bench top demonstration stage), laser risk reduction (which has developed

fundamental lidar technologies applicable to multiple NASA missions), and advanced information systems technology development (which provides advanced operations technologies which aid in reducing future mission costs).

The Decadal Survey, the U.S. Climate Change Science Program, and NASA's own planning in Earth science all assume the presence of an operational system of environmental monitoring satellites that can make climate-quality measurements. The Nation needs such a system. That is why NASA is a member of the NPOESS governing body, and why NASA entered into a partnership with the NPOESS Integrated Program Office to develop the NPOESS Preparatory Project (NPP). NPP is designed both to continue essential measurements from NASA's Earth Observing System satellites as well as provide a demonstration of instruments to be flown on NPOESS.

The Nunn-McCurdy certified NPOESS program, as you are aware, focuses NPOESS on its weather mission and deletes many of the capabilities previously planned for climate science. It is thus important to recognize that the NRC's work is not yet done. As the decadal survey committee was finalizing its notional mission set and sequence, the full impact of the removal of the climate sensors from the NPOESS program was just coming to light. In discussion with the NRC, NASA and NOAA have structured a follow-on activity wherein a subset of the decadal survey committee, augmented by others they may deem necessary, would hold a workshop and provide input on how the agencies might mitigate the impact of the changes to NPOESS. We expect that the NRC workshop will take place no later than early summer, in time to provide recommendations useful for helping to determine the FY09 budget.

NASA is proceeding with a mission roadmapping activity to determine the focus and content of our specific future Earth observing missions. The roadmap will integrate the scientific recommendations and priority/sequence of the Decadal Survey, the joint and ongoing NASA-NOAA examinations of the NPOESS Nunn-McCurdy changes, and the contributions of our international partners. Through a series of concept studies conducted at NASA centers (some actually begun in anticipation of the Decadal Survey mission suggestions), we are carefully examining the Decadal Survey's notional missions. The studies are assessing the technological readiness, system engineering challenges, and expected costs (including support for scientific validation and analysis of the mission data) of each notional missions. These concept studies are accessing the full capability of the NASA mission design and costing apparatus, to complement the estimates assigned by the NRC. As the roadmap evolves, community involvement will be assured through regular interactions with the Earth Science Subcommittee of the NASA Advisory Council, as well as existing discipline- and science-focus theme working groups which regularly inform our plans and examine our progress within the NASA Earth Science Division.

The roadmapping process includes the anticipated update later this year to the NASA Earth Science Plan. Indeed when the Congress asked the Agency for a Science Plan in the NASA Authorization Act of 2005 (P.L. 109-155), you recognized that the Decadal Survey would not be available in time to influence the Earth Science portion of that Plan. Therefore, NASA was asked to describe how it might revise that Plan based on the Earth science decadal survey. The roadmapping activity and the Science Plan will address that question.

While the scope and specificity of the roadmap clearly must exceed that of the Decadal Survey and must accommodate issues of programmatic balance and national needs, it is definitively ***not*** our intention to redo the Decadal Survey or to change the scientific priorities that it identified.

As with decadal surveys in other parts of the Science Mission Directorate portfolio, this Decadal Survey is only the starting point for planning. However, planning in Earth Science is

even more complex than in other divisions, given the web of partnerships and users of Earth science data, and its societal impact. Considering the long time horizon in the NRC's report, it will require several budget cycles to implement the program that we will derive from the Decadal Survey's near- and mid-term recommended mission sets. Nevertheless, our planning process starts with the consensus scientific priorities articulated for us by the NRC. So I will close by re-iterating my gratitude to the decadal survey committee Co-chairs and members for their excellent work. NASA's commitment to Earth science research is commensurate with theirs.

Table 1

NASA Earth Science Missions Currently in Development

NPOESS Preparatory Project (2009) Strategic mission; Systematic measurement	Ensures continuity of several key climate measurements between the Earth Observing System and NPOESS. Implementation of the NPOESS Presidential Decision Directive of 1994. Joint mission with the NPOESS Integrated Program Office.
Landsat Data Continuity Mission (2011) Strategic mission; Systematic measurement	Ensures continuity of long-term global land cover change data. Post-LDCM land imagery acquisition by an operational agency is planned. Joint mission with USGS.
Ocean Surface Topography Mission (2008) Strategic mission; Systematic measurement	Ensures continuity of ocean altimetry data; planned as part of a transition to operational agencies. Joint mission with NOAA, CNES & EUMETSAT.
Glory (2008) Strategic mission; Initializes a systematic measurement	Addresses high priority objective of the U.S. Climate Change Science Program. Measure global aerosols & liquid cloud properties and solar radiation. Mandated by the Presidential Climate Change Research Initiative of 2001.
Orbiting Carbon Observatory (2008) Competed mission; Earth System Science Pathfinder	Nearing completion of development. First global measurement of CO_2 from space; small Earth science mission.
Aquarius (2009) Competed mission; Earth System Science Pathfinder	In advanced stage of development. First global measurement of sea surface salinity from space; small Earth science mission. Joint mission with Argentina.
Global Precipitation Measurement (2013) Strategic mission - Initializes a systematic measurement	Recommended by 2005 interim report of decadal survey committee; extend spatial coverage to global and temporal coverage to every 3 hours with constellation
Earth System Science Pathfinder; TBD (2014) Competed mission	*Focus and relative priority to be determined using decadal survey;* solicitation no earlier than 2008 for 2014 launch.